An Overview of Pekan Lightning Detection System (PLDS)

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Abstract—**Pekan is located at east of peninsular Malaysia which experience very high cloud to ground (CG) lightning density. The lightning strike hazards can be properly managed by using a lightning location system (LLS). In this paper, a system to monitor the lightning strikes and thunderstorm has been installed and setup. Pekan Lightning Detection System (PLDS) has a combination of Magnetics Direction Finder and Time-of – Arrival sensor. The PLDS provides both real-time and historical lightning data .The real-time data include the time of lightning strokes, their location and an estimate of the peak current.**

Keywords-component; PLDS;Lighning Location System (LLS);Magnetics Direction Finding;thunderstorm.

I. INTRODUCTION

Lightning is a natural phenomenon that is of great concern to mankind and industry because of the detrimental impact on human safety, hazard and equipment failure due to AC main power conducting electrical transient. The Lightning Location System (LLS) can be used to minimize the harmful effects of lightning by providing early warning of such lightning hazards.

The LLS systems have collected a large number of data on the time, location, lightning coordinates, amplitude, polarity of the CG flashes and number of stroke per flash [1]. LLS are being operated in many countries, including the U.S. [2], U.K. [3], Japan [4], Canada [5], Austria [1], Sweden [6], China [7], Indonesia [8], Malaysia [9] and other countries.

There are more than 60 LLS networks worldwide [10] that employ commercial instrumentation operating in the VLF/LF range. Most of these networks employ IMPACT sensors and focus primarily on CG lightning. Examples of large networks include the multinational European networks called EUCLID [11], [12] and LINET [13], the Japan Lightning Detection Network called JLDN [14], the Brazilian National Network called BrasilDAT [15], the Canadian Lightning Detection Network called CLDN [16],the South African national network [17] and long-range lightning detection network Zeus[18], with receivers located in Europe and Africa.

The highest resolution CG LLS networks are the Austrian Lightning. Detection Network called ALDIS [1], which also contributes to the EUCLID network; portions of the LINET network in Europe [19] .A number of locally manufactured LLSs are located in China such as GDLLS [7].

The LLS data are primarily used by power utilities and also used in weather service, aviation, forest service, geophysical research and others applications [7]. Data from the Zeus [18] network are currently being applied in meteorology, hydrology and global climate studies. While one of the U.S NLDN [10] applications was used to assess the power line faults and failures as part of a broad national initiative to improve power quality and reliability since 1993.

In this paper, the overview of the PLDS has been described. The real-time data include the time of lightning strokes, thunderstorm, their location and an estimate of the peak current has been discussed.

II. PLDS

A. Overviews

Pekan is the royal town of the Malaysian state of Pahang Darul Makmur, its geographical coordinates are 3° 50' North, 103° 41' 27" East. The province has an area of $3805 km^2$ with total population is estimated about 120 000 people in 2006. The population of mukim Pekan is mainly Malay dominated. The Bumiputra comprised 88.1 percent (77.2 percent Malay and 10.9 percent Orang Asli) of the total population, the Chinese and Indian being 2 and 1 percent respectively and the Cambodians made up the remaining 8.9 percent. [22]

Lightning is a common phenomenon in Pekan region which located at coast of Laut China Selatan. The populations in this area consist of fishermen who make a livelihood from the sea and industrials park which exposed to damage that cause by lightning. The information about lightning occurrences at this region might help these people to buckle up during lightning. It is important to understand the phenomena and characteristic of the lightning because lightning cannot be prevented.

The purpose of developing PLDS is to publish real time lightning data in 50km radius from the sensor which is located on the rooftop of Faculty of Electrical & Electronics Engineering (FKEE) UMP Pekan. This facility can contribute to safety and knowledge of lightning to people in this region as the purpose of this project

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B. *System Installation and Setup*

At the early of 2012, a lightning detection system based on Magnetic Direction Finder and Time of Arrival was first installed in Pekan. Then the system was renowned as Pekan Lightning Detection System (PLDS).

The system consists of three major parts, including the combination of magnetic direction and time –of- arrival finder antenna, receiver and lightning location information analysis and GUI system. The sensor was located on coordinate 3° 32' 0" North, 103° 28' 0" East which is Block 1, FKEE, Universiti Malaysia Pahang, Pekan campus.

The sensor should be mounting on the correct side to face north and at least 25 feet above ground. The front of the sensor corresponds to the top of the computer screen. If the sensor does not face north the top of the map on computer screen will be miss alignment.

The installation also must free from any barrier especially large metal object which can block the radio signals because it will reduce the range of detection. The cable network is directly connected to the sensor receiver detector which is placed at the F3 laboratory room. Fig.1 shown the sensor has been setup on the FKEE rooftop building.

Figure1. Sensor on the rooftop building of FKEE, UMP, Pekan

This lightning location information analysis and GUI can be used to replay lightning achieve files created by the system. The system can detect, analyze real time lightning data and also summarizes of daily lightning distribution within the sensor zone [12]. Fig. 2 showed the GUI of the PLDS system that has been installed at UMP Pekan.

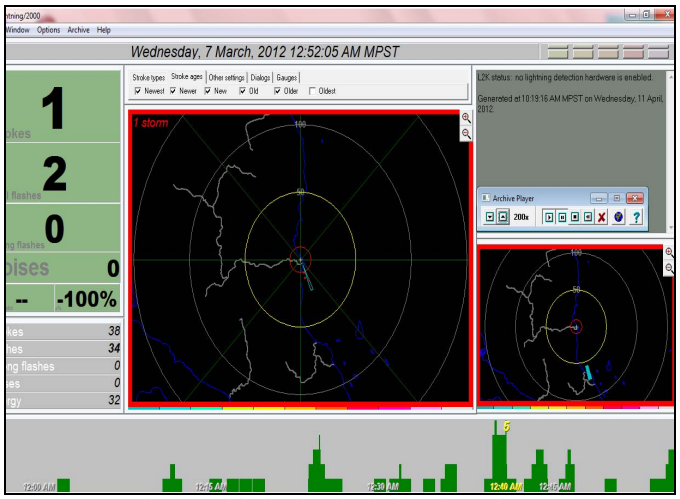

Figure2. Lightning location information and GUI

C. *Method of Lightning Detection*

There are three most common electromagnetic radiofrequency locating techniques, magnetic direction finding (MDF), time of arrival (TOA), and interferometry, the type of locating information obtained depends on the frequency of the radiation detected [9]. TOA for locating lightning can be divided into three general types: First is very-short-baseline (tens to hundreds of meters), followed by short-baseline (tens of kilometers), and lastly, long baseline (hundreds to thousands of kilometers).

The PLDS system is used a sensor which consist a small active antenna to receive the EMF and E-field from lightning strikes. The sensor detection is based on the magnetic direction finder (MDF) and time-of-arrival technique to detect the lightning. It consists of two orthogonal magnetic loops from which the source azimuth can be deduced. The source location is then estimated by the triangulation technique [20].

The sensor operates by sampling North-South and East-West component of the return stroke magnetic field at the initial peak using the 2 orthogonal loops. This method does not contain the polarization error in the recorded result. The magnetic antenna systems and direction finding electronics are simple, reliable, and easy to conduct using modern solid-state component. [21]

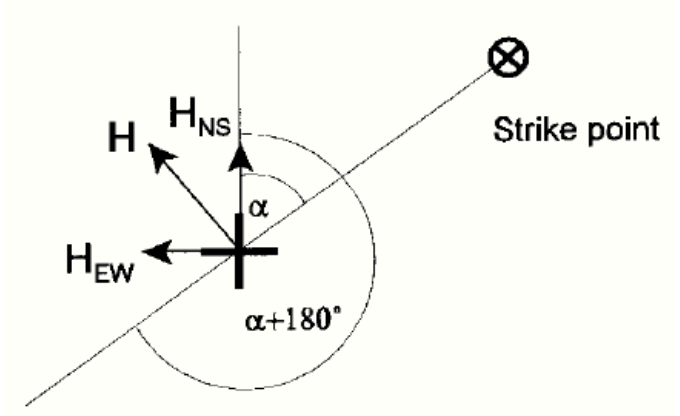

Figure3. Determination of the Angle to the Lightning Strike Point [1]

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The direction of lightning strike is usually determined by using a pairs of loop antenna which is place perpendicular to each other (Fig.3). Each of the loop antennas is used to sense the magnetic field produce by the lightning strike. The angle to the lightning strike point is determined by the ratio from the two loop antennas with the following formula

$$\tan \alpha = \frac{H_{NS}}{H_{EW}} \quad (1)$$

III. PLDS REAL-TIME FEATURES

There have several features that make PLDS is a unique. The systems can analysis the raw lightning data to the real-time lightning data. PLDS are able to detect and analyze real-time lightning data and can be displayed both textually and graphically. It is able to process all available sensor information in real time, and thus can compute a separate location for each individual stroke in the flash.

A. Real-time Lightning data

The incoming of lightning strokes are analyzed using a variety of statistical techniques. The border of the window will change the color either yellow or red to give an alert. When such flashes are detected, a special "storm" is depicted. Rather than being a wedge shape, these special nearby storms are circular or elliptical. When one of these storms is shown, there is an excellent chance that lightning is imminent or is occurring in the immediate area.

B. Threat Ascessment

The Threat Assessment window is a depiction of storm activity over the last 5-20 minutes. The information in this window is based on the average position of all lightning flashes detected in the last 5-20 minutes. The average range of all strokes in a similar direction is used to calculate the placement of the colored areas in the Threat Assessment window. Through this averaging technique, a more realistic appraisal of storm activity can be determined.

C. Stroke rate Graph

The stroke rate graph shows at a glance the rate of change of lightning activity. Users are able to change the length of time that the graph comprises from 15 minutes to 24 hours by right-clicking on the graph. The peak activity (within the length of the graph) is indicated with a text label. Several other text labels indicate the time at various points over the period covered by the graph. The Stroke Rate History window is very useful for spotting trends in storm activity. A sudden increase in the flash rate can be clearly seen. Also, a sudden surge in the fraction of +CG strokes or –IC strokes becomes obvious, and can be an indicator of a severe thunderstorm.

D. Rates

The window rate shows six counter displays. The total flash rate counter, the strong stroke rate counter, the noise rate counter, the stroke rate percentage change counter, and the stroke rate counter. The stroke rate counters are updated as often as once every one-tenth of a second. The stroke subtype percentage counters are updated as often as every half second, as are the stroke rate change counters.

IV. RESULT AND DISCUSSION

By using PLDS, the daily summary will be provided. The total strokes, flashes, noises and energy are calculated by the software every 24hours. The software will display in yellow or red alert when there is stroke nearby where the sensor are locate. The yellow alert will trigger when the stroke within 50km radius while the red alert trigger in 10km radius from the located sensor. The triggering level was set during the software initial setup.

Data summarized for March 2012 are shown in the table 1 below which is indicate by the sensor. Data collected in two different ranges which is indicate in yellow alert for 50km radius and red alert within 10km radius. This summary is saved automatically at midnight each day.

TABLE I. GENERAL ALERT ON MARCH 2012

Date	General alert	
	Yellow	Red
1/3/2012	15.2 min	0
2/3/2012	2h 21.3 min	0
3/3/2012	1h 10.2 min	0
4/3/2012	2 min	0
5/3/2012	1h 20 min	0
6/3/2012	1h 33 min	0
7/3/2012	38 min	0
8/3/2012	1h 35 min	0
9/3/2012	1min	0
10/3/2012	0	0
11/3/2012	0	0
12/3/2012	0	0
13/3/2012	0	0
14/3/2012	0.9 min	0
15/3/2012	1.8 min	0
16/3/2012	1 min	0
17/3/2012	0	0

18/3/2012	0	0
19/3/2012	0	0
20/3/2012	0	0
21/3/2012	1h 16.3min	0
22/3/2012	0	0
23/3/2012	1min	0
24/3/2012	0	0
25/3/2012	0	0
26/3/2012	0	0

Table 1 indicates the general alert summarize result collected by PLDS for March 2012. Data is displayed in time which mean how long does it takes for lightning occurred in that region.

Fig.4 showed the thunderstorm activity coming from the SE region on 8th March 2012 at 3:41 Am. Based on the data captured by the system, the average current amplitude strength is 27.3kA. The thunderstorm activity is coming from the sea and it moving between 6 to 20 km distances from SE Kuala Pahang.

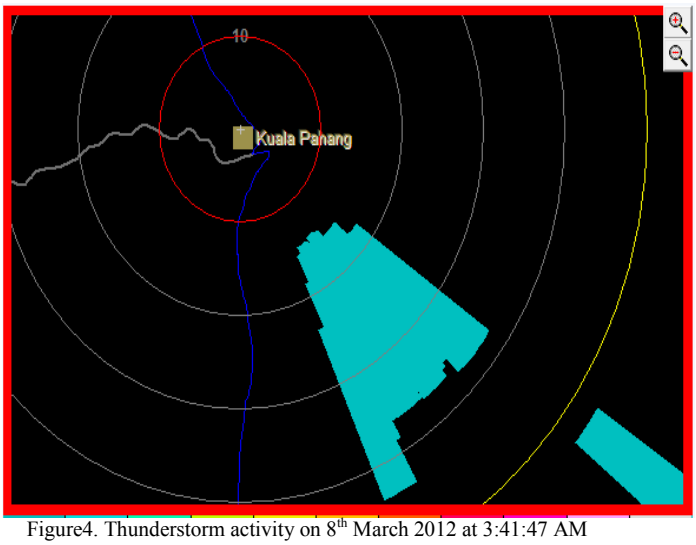

Figure4. Thunderstorm activity on 8th March 2012 at 3:41:47 AM

The storm alert indicates the total time of storm activity inside the sensor range. Storms with a relatively small number of strokes are subject to fairly large uncertainties in their range. When an individual lightning flash is relatively nearby became possible. When such flashes are detected, a special "storm" is depicted. Rather than being a wedge shape, these special nearby storms are circular or elliptical. When one of these storms is shown, there is a 100% chance that lightning is imminent or is occurring in the immediate area.

TABLE II. STORM ALERT ON MARCH 2012

Date	Storm Alert	
	Yellow	Red
1/3/2012	1h 14.3 min	14.1min
2/3/2012	2h 39.6 min	2h 21.8min
3/3/2012	1h 8.3 min	1h 10.6min
4/3/2012	38.1 min	2min
5/3/2012	1h 23 min	1h 19.5min
6/3/2012	21.1 min	1h 33.4min
7/3/2012	3h9.1 min	37.4min
8/3/2012	50.3 min	1h 33.9min
9/3/2012-30/3/2012	0	0

Table II indicates the storm alert collected by PLDS during 1st March 2012 until 30th March 2012. The general status describes thunderstorm activity as being either nearby, regional, or distant. A nearby storm is one that is depicted as being inside the red alert. A regional storm is one that is depicted as being inside the yellow alert distance. This alert triggered when one or more condition based on the other alert occurs. A general red alert does mean that a thundershower or thunderstorm is likely to be nearby. The general red alert remains in effect for at least 5 minutes.

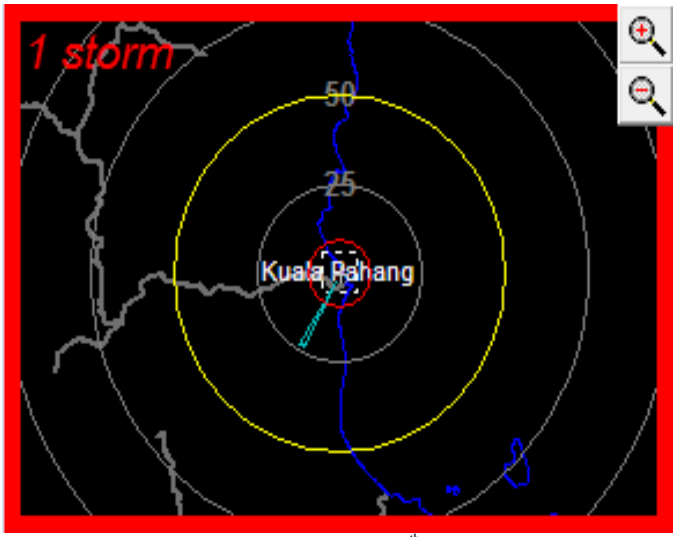

Figure5. Real time and storm analysis data on 6th March 2012 at 18:10 PM

All the lightning and storm activity has been saved in data based system. The achieved data was stored every 24 hours and it can be playback every time including the real time data. Fig.5 shows the red alert because PLDS has detected one nearby storm in range of 25 km radius on 6th March 2012. Table III below shows the real time data for averaged

lightning peak current amplitude for selected date from March 2012.

TABLE III. AVERAGED OF LIGHTNING PEAK CURRENT IN PEKAN

Date	PLDS	
	Time	Lightning peak amplitude(kA)
2/3/2012	17:36:26	26.8
6/3/2012	17:35:34	24.1
6/3/2012	17:53:55	29
6/3/2012	18:02:04	28.4
6/3/2012	18:34:31	40.2
7/3/2012	17:53:21	32.4
8/3/2012	4:01:45	42.1
8/3/2012	4:18:54	14.4
8/3/2012	5:06:40	63.9
8/3/2012	5:29:28	76.9
21/3/2012	14:09:09	38.9
21/3/2012	14:16:51	15.1
21/3/2012	17:07:35	25.5
27/3/2012	17:25:27	20.6
27/3/2012	17:33:42	22.5
27/3/2012	17:45:41	21.4
29/3/2012	17:01:19	36.7
29/3/2012	18:42:58	23.6

The highest current amplitude was recorded on 8th March 2012 at 5:06:40 AM which is 76.9kA. Fig. 6 showed the active lightning activity in 25 km radius within Kuala Pahang during that time. That why the biggest current amplitude was recorded there. The red alert display also showed that the storm was moving from SE to Kuala Pahang .

Mostly the average current amplitude was recorded by the system is between 24.1kA to 28.4 kA. The current amplitude is very high because Kuala Pahang is facing the sea of Laut China Selatan.

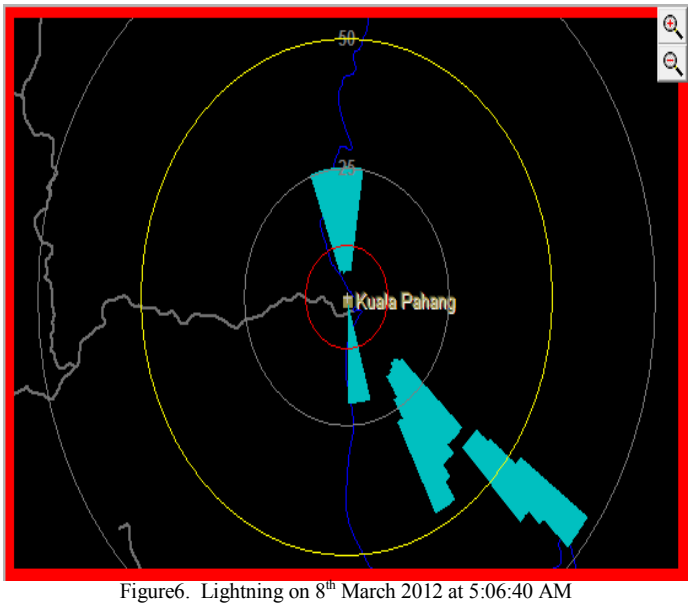

Figure6. Lightning on 8th March 2012 at 5:06:40 AM

V. CONCLUSION

The function of PLDS is to estimate the lightning occurred specific to particular locations in 50km radius from Pekan. It is important for public to understand the phenomena and characteristic of the lightning for mitigation of lightning related problems. This project is an early development for the town residents to begin their daily activities more careful, especially on the thunderstorms days. PLDS are able to detect and analyze real-time lightning data. The data can be displayed both textually and graphically. The information about lightning occurrences at this region can help civilian to buckle up during lightning.

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